Space Weather Technical Forecast

Issued on Tuesday 25 February 2025 at 13:17 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Isolated M-class flares likely. Slight chance G1/Minor Storms, mainly Day 4 (28 Feb). S1 Minor Radiation Storm easing, with chance of further enhancements.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate with four M-class flares, including two notable long-duration events. These were an M3.9 peaking 24/2302 UTC from over the southwest limb and an M3.6 peaking 25/1159 UTC from AR3996/AR3998 in the southwest. AR3998 is the most notable of the eleven sunspot regions on the Earth-facing disc, with a number of small umbrae and ongoing evolution, but a largely simple bipolar magnetic configuration with some maturation of the region likely occurring. The other regions are generally smaller and simpler, with the main exceptions being AR4000 in the northwest and AR4006 in the northeast, although these are also relatively simple regions with only limited growth.

The M3.9 flare produced a large and fast CME, however this was far-sided. The M3.6 flare has likely produced a CME, and will be assessed once coronagraph imagery is available

Solar Wind / Geomagnetic Activity: Solar winds were indicative of ongoing slow wind, but with a likely transient CME enhancement. Solar wind speed, as measured by ACE at L1, was background to slightly elevated, rising from 350 km/s at first to peak around 420-450km/s at 24/1900 UTC, before easing back to 370-410km/s. Density was near average at first, but rose to above average from around 25/0000 UTC to peak near 20ppcc, before easing back to near or below average. Interplanetary Magnetic Field, Bt, was Moderate to Strong, peaking 18nT between 24/2000-25/0010 UTC, before erratically easing to range 6-12nT. This was predominately positive (northward) but with a southward (negative) period 24/1200-1830 UTC, ranging -13nT to +14nT. Phi angle was mostly negative (towards the Sun) but with a period of positive 24/1800-25/0800 UTC. Geomagnetic activity was mainly Quiet (Kp1-2) but Unsettled to Active (Kp 3-4) between 24/1800-25/0000 UTC.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) at GOES18 rose in response to the far-sided M3.9 flare, giving a period of S1 Minor Radiation Storm 25/0020-1125 UTC with peak 37 pfu at 25/0240 UTC. A gradual decaying trend has since been observed. The associated 24-hour fluence was below the Active threshold (1e8 integrated pfu). recording 1.56e6 integrated pfu at 25/0000UTC.

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Four-Day Space Weather Forecast Summary

Solar Activity: Moderate solar activity is forecast, with isolated M-flares considered likely and a slight chance of X-flares.

Solar Wind / Geomagnetic Activity: No CMEs are currently forecast to be Earth-directed, however a weak CME from the M3.3 flare and filament eruption early on 24 Feb has the potential to give a glancing impact day 3 (27 Feb). Imagery is needed to assess any potential from the likely CME from the M3.6 flare peaking 25/1159 UTC. Otherwise, a sequent of coronal hole fast wind enhancements are likely, with current mainly background slow winds likely becoming Slightly Elevated through day 2-3 (26-27 Feb) and then becoming Strong day 3-4 (27-28 Feb). However, geomagnetic activity from these is likely to be subdued due to their polarity. Quiet to Unsettled expected, with a chance of Active intervals, and a slight chance of G1 Minor storms, most likely day 4 (28 Feb).

Energetic Particles / Solar Radiation: High energy proton flux is currently just below the S1 Minor Storm level, and is expected to be initially declining. However, there is the potential for a further enhancement day 1-2 (25-26 Feb) due to the M3.3 flare at 25/1259 UTC from the southwest disc or any further large flares from over the west limb. There is a slight chance of further enhancement given any further notable flares, most likely from AR3998. High energy electron flux is expected to be mainly at Background. The associated 24 hour fluence is expected to remain below the Active (1e8 integrated pfu) threshold.

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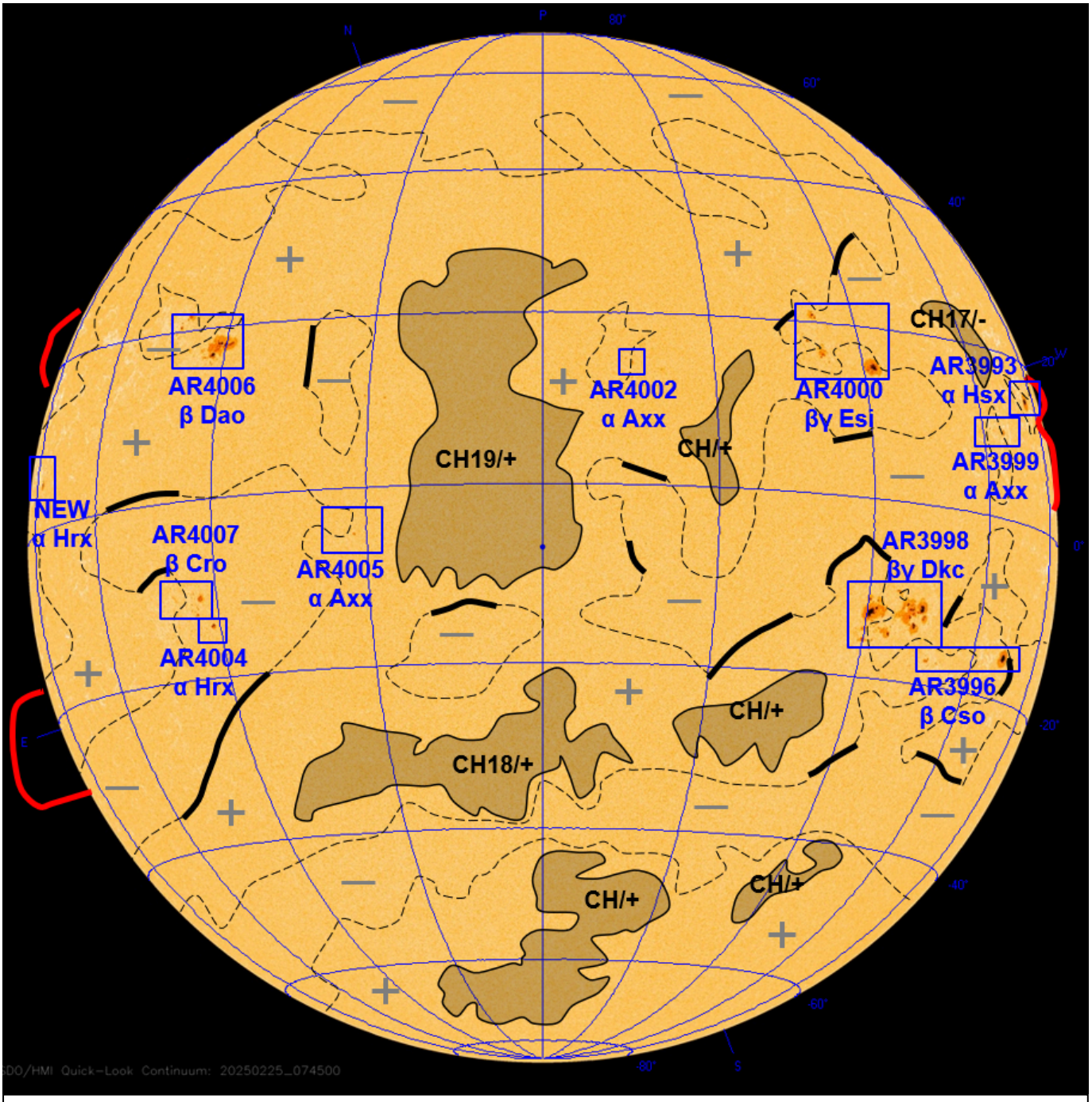
Figure 1: MOSWOC Solar Synoptic Map 25/0800 UTC



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

The fast and bright CME off the northwest on 24 Feb, obscures a much weaker and fainter signal from the M3.3 flare and associated filament eruption. This signal is identifiable on STEREO A cor2 difference imagery, however this is likely missing passing north and ahead of Earth. However, due to the contamination from the far-side event, this assessment is low confidence, and a glancing influence cannot be completely ruled out, most likely to occur early on day 3 (27 Feb). The other CMEs featured in previous forecasts have likely impacted or now passed.

Solar winds at Earth are currently near Background speeds, with slow wind conditions dominating. There are a large number of coronal hole features currently on the Earth-facing disc. However, aside from CH17/- in the northwest, all the features are positive polarity coronal holes which are less favoured for strong a geomagnetic connection to Earth as we move closer to the March Equinox. Initial enhancement is most likely the currently unnumbered leading regions, perhaps though day 2 (26 Feb), with Slightly Elevated solar winds expected. A further enhancement is then likely on day 3-4 (27-28 Feb), due to the onset of any fast wind from CH19/+ (and CH18/+ in the south). This is a larger and more notable feature, and last rotation brought solar wind speeds of over 600km/s, but only Active geomagnetic activity. Despite the proximity of the equinox, the persistence of this feature suggests similar can be expected on this occasion, with a slight chance isolated G1 Minor Storm intervals.

Generally Quiet to Unsettled activity is expected. Active intervals are possible however, along with the slight chance of G1 Minor Storm intervals, either from ongoing CME influence day 1 (25 Feb), any further CME glance day 3 (27 Feb), as well as any coronal hole fast wind onset day 2-3 (26-27 Feb) and more likely day 3-4 (27-28 Feb).

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	5	10	20
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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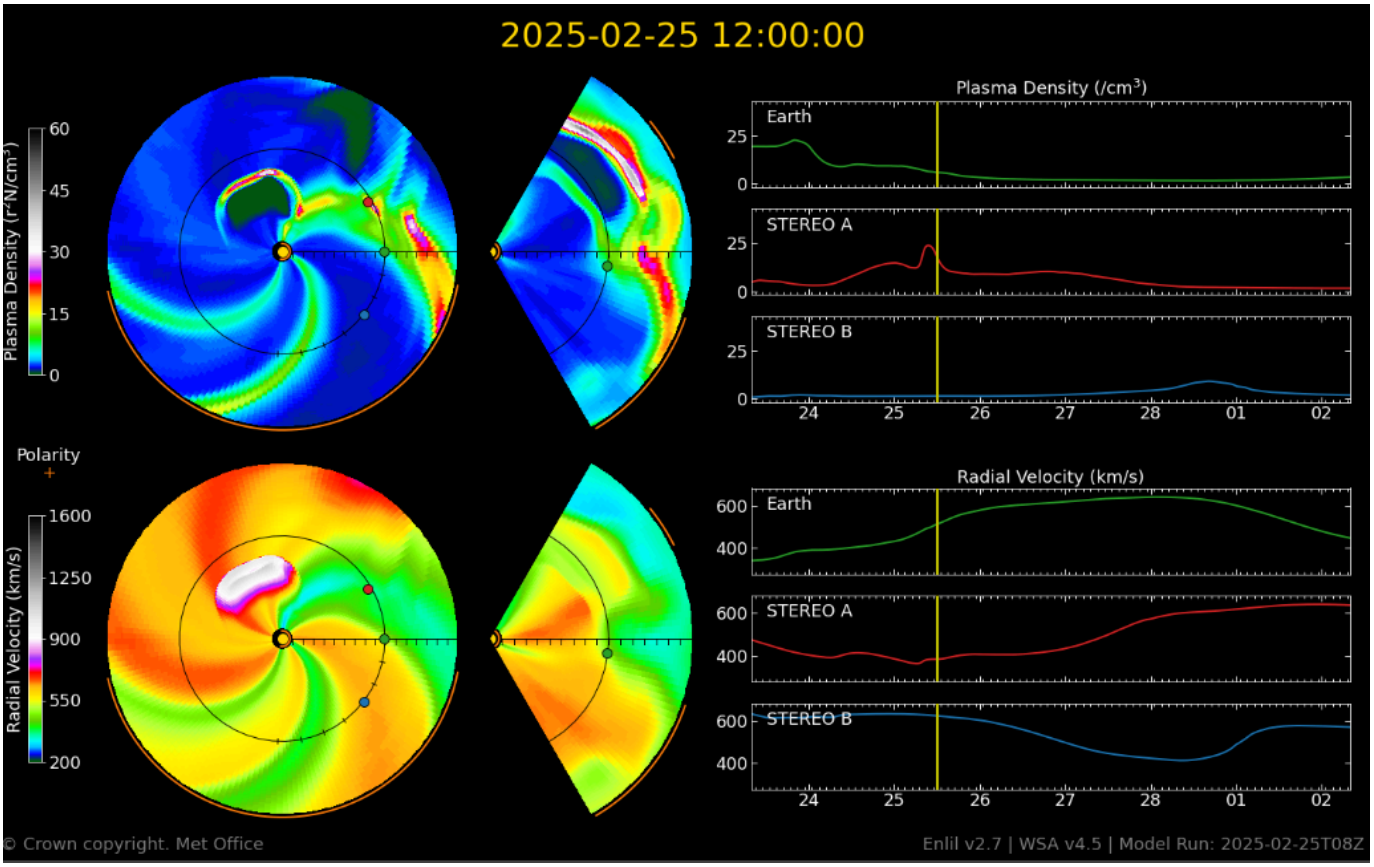
Figure 2: MOSWOC Enlil , showing onset of fast winds, but too early and broad compared to expectations. Peak winds are expected 28 Feb, however.



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Radio Blackouts - X-Ray Flares

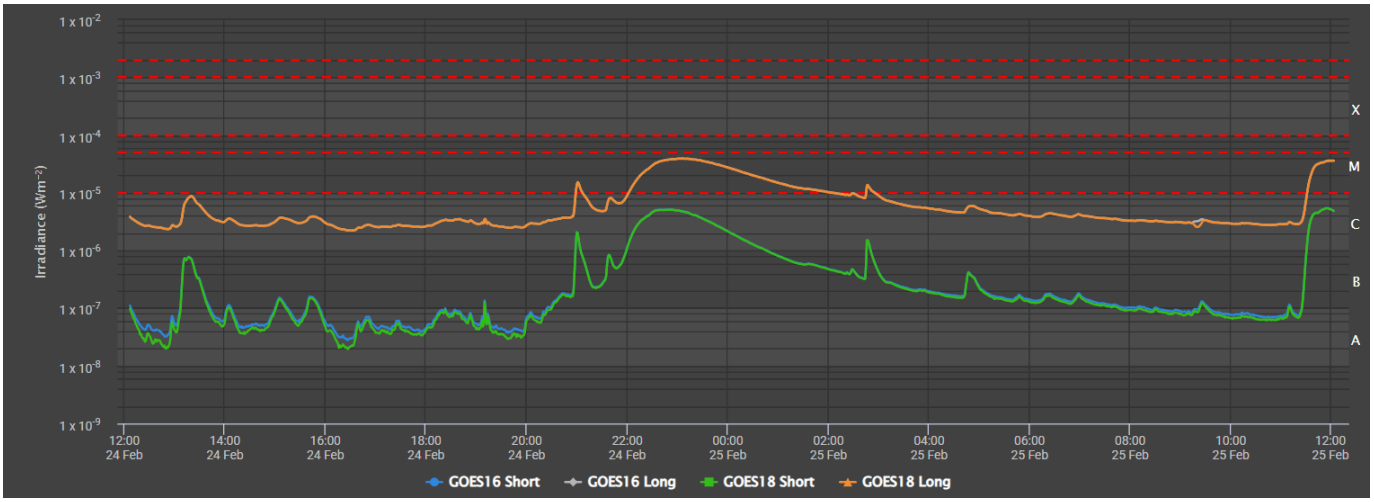
There are eleven active regions on the visible disc, however the most notable recent activity has been from over the west limb. This includes the X-class flare on 23 Feb and the long period M-3.9 flare on 24 Feb. Further activity remains possible from over the limb on day 1 (25 Feb) before this risk quickly declines.

The most likely flare source on the visible disc is AR3998 in the southwest. This is the largest region on the disc, primarily comprised of a number of small umbrae with penumbra, however this region be maturing with the individual spots coalescing into larger regions, and a developing a more typical bipolar configuration. This region, and its interaction with the simplifying AR3996 to its south, was the source of the period M-class flare on 25 Feb.

The other regions of main interest include AR4000 in the northeast, with some mixed polarity intermediate spots, and AR4006 in the northeast, which has seen some growth of its main leader spot but remains relatively simple. The other regions are smaller and simpler with only limited growth. Overall, Moderate activity is likely, with further isolated M-class flares.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	70	70	70	70
Very Active	R3-R5 (X Class)	No	10	10	10	10

Figure 3: GOES-16/18 X-ray Irradiance



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Solar Radiation Storms (High Energy Protons)

GOES-18 high energy (>10MeV) proton flux reached the S1 Minor Radiation Storm level due the large far-sided eruption and subsequent flare of M3.9 peaking at 24/2302 UTC and visible from over the northwest limb. This has since declined, with the proton flux likely to continue easing towards background. However there remains a chance of further enhancements if any further far-sided activity occurs. This potential is also increased due to AR3998 in the southwest, along with a number of other active regions on the Earth-facing disc.

The recent long-duration M-class flare from AR3998/AR3996 shortly before 25/1200 UTC also brings an increased potential for proton enhancement.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	100	25	15	10
Very Active	**≥ S3 ***	No	5	5	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES-18 proton flux

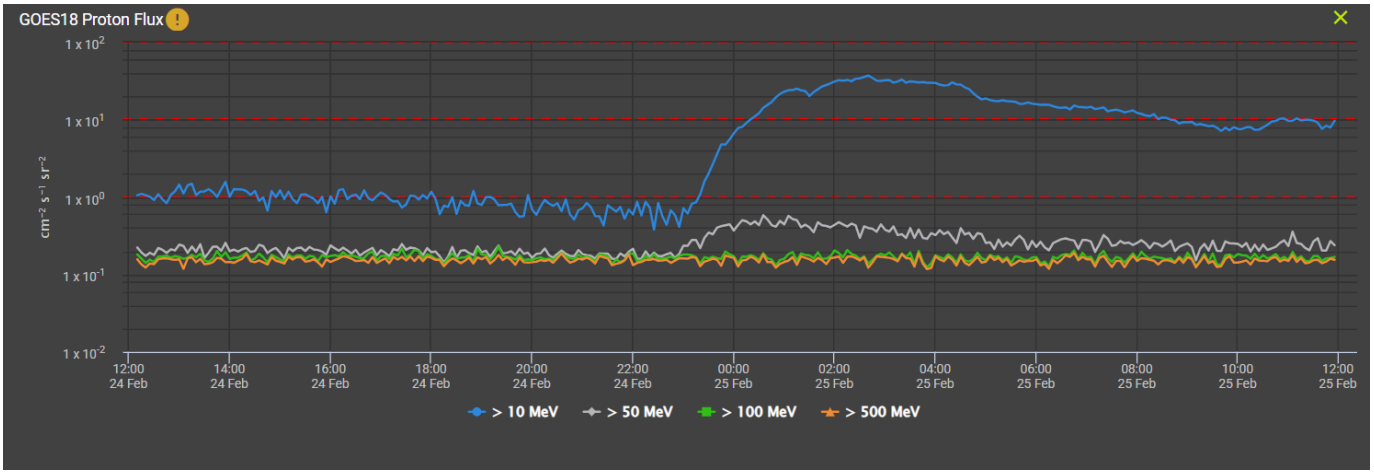

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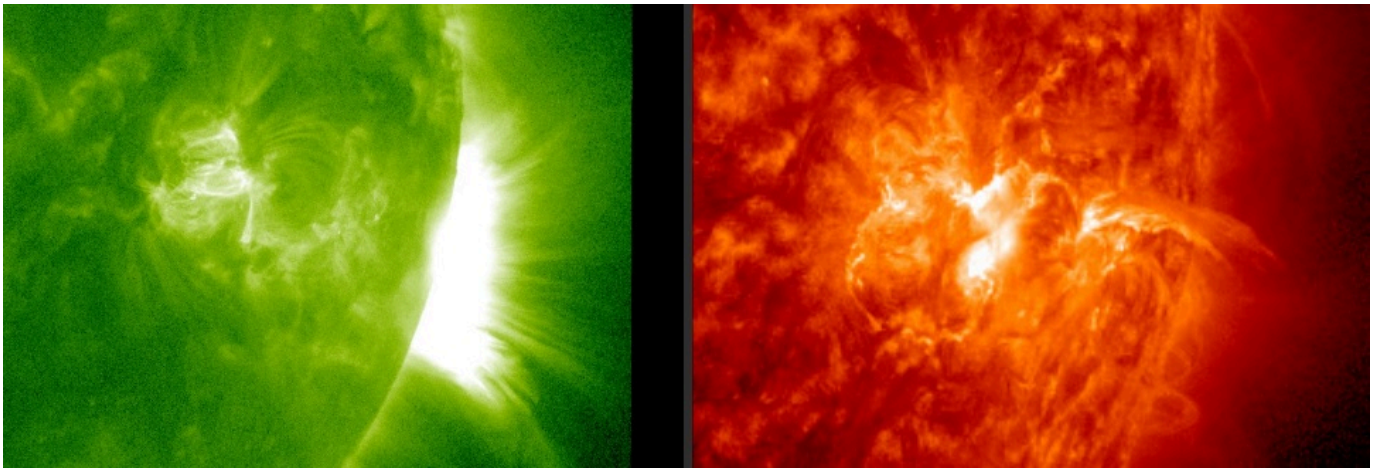
Figure 5: SDO aia-94 of long duration M3.9 from over SW limb peaking at 24/2302 UTC (lef). SDO aia-304 of long duration M3.6 (peaking 25/1159 UTC) from the southwest disc.



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High Energy Electrons (≥ 2MeV)

High energy electron flux, as observed at GOES-16, is at background, with recent weak CME arrivals perhaps helping to suppress electron flux. With no major source of charging of the electron belts expected over the coming days, electron flux is expected to remain at similar levels.

The associated 24 hour fluence is currently below Active. This is expected to continue as suggested by MOSWOC REFM, which is currently providing reasonable guidance.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	1	1	1	1
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

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